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     When a Military Service no longer needs an item of industrial plant equip-
ment, it is offered to the Defense Industrial Plant Equipment Center's (DIPEC's)
General Reserve, where it may be kept for mobilization or repaired and reissued
for reutilization in current production, in lieu of purchasing a new item. When
an item is offered, DIPEC must decide whether to (1) retain it for mobilization/
reutilization or (2) dispose of it on the open market. If retention would be for
                                                              (continued)

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IMPROVING INDUSTRIAL PLANT
EQUIPMENT RETENTION DECISIONS

November 1983

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Executive Summary

IMPROVING INDUSTRIAL PLANT EQUIPMENT RETENTION DECISIONS

An internal Defense Logistics Agency (DLA) study questions procedures used by the Defense Industrial Plant Equipment Center (DIPEC) in deciding whether to (1) take possession of (and generally recondition) an item of Government-owned industrial plant equipment (IPE) no longer needed by a Military Service, or (2) sell it on the open market. We find DLA's concern to be well founded. The requirements determination underlying the decision, and the economic factors used for it, are faulty.

The Military Services maintain IPE in government or contractor plants to support current production or to provide a reserve for defense emergency production. When a Service decides that IPE is no longer needed, it is offered to DIPEC, which maintains a General Reserve. The General Reserve is for two purposes: 1) mobilization, supplementing IPE kept for that purpose by the Services; and 2) reutilization for on-going production in contractor- or Government-owned plants in lieu of purchase of new equipment.

If the item is being considered for mobilization requirements only, DIPEC's decision to retain or dispose of it is made judgmentally, in the light of pre-determined mobilization requirements. If the item would be for reutilization or both mobilization and reutilization, DIPEC uses an economic evaluation system that compares costs of reconditioning and savings from retention. Thus, DIPEC's retention evaluation method is dictated by its requirements determination.

We found requirements determination arbitrary and lacking in credibility in several respects. Mobilization requirements are based on historic peak

utilization and may bear little relationship to current mobilization requirements and to what is available to satisfy them. Reutilization requirements are based solely on user demands on DIPEC and do not reflect DIPEC's receipt of IPE that can be used to satisfy those demands.

Application of DIPEC's economic evaluation system results in an unrealistic bias toward retention, largely because it overstates the value of used equipment. To compensate, many economic decisions in favor of retention are overridden by the application of subjective criteria.

We recommend a careful redetermination of requirements for both mobilization and reutilization. We concur with DIPEC's judgmental framework for retention decisions to satisfy mobilization requirements, because mobilization needs are dependent in large part on non-economic factors. For reutilization, however, we recommend replacing DIPEC's present economic evaluation system with a comparison between (1) the cost of reconditioning an item and (2) the fair market value of the item in ready-to-use condition (the item being retained if the reconditioning cost is less than fair market value). Both reconditioning costs and fair market value should be determined by independent appraisers.

We also recommend that the costs of handling, storing, and reconditioning be charged to the user requesting the item. In that way, the user's choice between an old and a new item would better reflect the true costs to the Department of Defense (DoD).

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1. INTRODUCTION

The Military Services maintain in their custody a stock of industrial plant equipment (IPE) in their own or contractor plants. This equipment supports current production or is in reserve for defense emergencies. When a Military Service concludes that IPE under its control is no longer needed, it is offered to the Defense Industrial Plant Equipment Center (DIPEC). Excessing items of equipment to DIPEC occurs because (1) they are no longer capable of or needed for supporting current production or (2) the nature of equipment needed to meet defense emergencies has changed. The Military Services are required to obtain, if available, suitable items of IPE from DIPEC in lieu of purchase of new equipment. Thus, DIPEC serves as a central Department of Defense (DoD) storage and clearinghouse operation, both (1) maintaining a stock of critical machine tools that may be needed for industrial mobilization and (2) repairing and reissuing equipment for reutilization.

DIPEC is required by law to maintain a General Reserve of IPE beyond the stock maintained by the Military Services to meet their requirements under their mobilization plans. The Defense Industrial Reserve Act of 1973 (P.L. 93-155) directs the Secretary of Defense to maintain ". . . an essential nucleus of Government-owned plants and an industrial reserve of machine tools and other manufacturing equipment . . . for immediate use and to supply the needs of the Armed Forces in time of national emergency or in anticipation thereof . . . ." DIPEC has been further instructed to ensure that maximum reutilization of this equipment occurs. Department of Defense Directive (DoDD) 4215.18 assigns responsibilities for managing DoD-owned IPE to the Defense Logistics Agency (DLA) and further directs that it act as a

clearinghouse for all DoD-Component requirements for IPE, to ensure ". . . optimum reutilization or disposal."

Within this charter of responsibilities, DIPEC faces a number of constraints. It has no control over the number, types, or condition of items of equipment offered to it. Management of the General Reserve is limited to retaining or disposing of items offered by the Military Services. It is required to offer its inventory in support of current production. Reutilization of equipment represents consumption of the mobilization stock.

In 1981, Headquarters DLA, DIPEC's parent organization, reviewed IPE management and operations.[1] This study concluded, in part, that a review should be conducted of DIPEC's current methods for deciding which offered items of IPE it retains. DLA was particularly concerned with certain aspects of DIPEC's evaluation of economic benefits and costs, called the Retention Evaluation System, associated with decisions to add and retain items in the General Reserve. A major factor of economic benefit is the current value placed on used equipment. DIPEC's method of assigning current value has been criticized as not fully reflecting obsolescence, technological change, efficiency, and remaining service life. Logistics Management Institute (LMI) was asked to (1) review DIPEC's Retention Evaluation System for its validity in making retention decisions for the General Reserve and (2) suggest an alternative methodology to correct any deficiencies found in theory or in practice in the current system.

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[1]Headquarters DLA Review of Industrial Plant Equipment Management and Operations, January-November 1981, Defense Logistics Agency, Cameron Station, Alexandria, Virginia.

2. RETENTION EVALUATION SYSTEM

GENERAL

The heart of DIPEC's retention decision making is the application of the Retention Evaluation System, which is employed when a Military Service offers DIPEC an idle piece of IPE to determine whether to retain it in inventory or dispose of it by sale.

The Defense Industrial Reserve Act of 1973 states that the primary purpose for maintaining a General Reserve is to provide for mobilization requirements. There is, however, a secondary purpose for retaining IPE: to provide it to the Services and contractors for reutilization, in order to avoid the cost of buying a new item.

Reutilization and mobilization requirements are developed for each category of IPE, and the greater of these two numbers becomes the desired number to be held in the General Reserve, the desired retention level or inventory. Requirements and desired retention levels are developed for· approximately 4000 separate categories of equipment. The type of retention evaluation that DIPEC conducts is determined by the prevailing requirement -- to add an item to the General Reserve to satisfy mobilization requirements, reutilization requirements, or both.

The Services do not supply DLA with mobilization needs. Each Service maintains its own system of standby plant equipment packages and other IPE for mobilization. Neither the Services nor the Office of the Secretary of Defense provide DIPEC with accurate estimates of mobilization requirements for IPE in the General Reserve. DIPEC has developed its own mobilization requirements, based on production data from a peak year, 1968, when Vietnam War production was highest. These requirements are found as the difference between the level

of IPE in active use in 1968 and the level in active use today. Thus, the General Reserve mobilization requirement today is the deficit between peak use and today's active inventory.

The reutilization requirement is calculated by multiplying the last three years' demand for a DIPEC category of equipment by two. Thus, the reutilization requirement is based on maintaining a General Reserve inventory of six years of reutilization demand.

If the reutilization requirement for a category of equipment has been satisfied and the mobilization requirement has not, the next item of IPE that is offered is obviously for mobilization only. The decision criterion for retention to satisfy a mobilization requirement is different from the economic criterion used to evaluate retention for reutilization. In the case of reutilization, DIPEC tries to answer the question of whether or not it is economic to retain, repair, and reissue the item for reutilization rather than have a user purchase a comparable new item at today's price. In the case of adding an item for mobilization, DIPEC tries to answer the question of whether the item is useful or could be made useful in the event of mobilization. The tendency is to keep an item to satisfy a mobilization requirement, knowing that it may not be possible to buy a comparable item in the event of mobilization.

The evaluation is non-economic and judgmental because mobilization involves many considerations other than economic ones. A rationale for the decision is given by the evaluator and most often addresses factors such as equipment condition, estimated cost to repair, availability of spare parts, and a general appraisal of the predicted need.

LMI sampled 300 retention/disposal decisions made over a 10-week period. Fifty percent of the IPE analyzed judgmentally for mobilization purposes was retained, compared to 25 percent when an economic model was applied.

Recognizing that the decision to retain a piece of IPE for reutilization is an economic one, DLA has developed an economic decision model to assist in decision making. When a Service declares a piece of IPE idle, DIPEC must decide either to add or not add it to the reserve. DIPEC refers to the model as the "add model".[1]

When IPE is offered, DIPEC reviews on-hand requisitions to see whether the IPE can be forwarded directly to a requesting component. If there is no match, spare parts availability is checked to ensure that the IPE is capable of being maintained. If no parts are available, the IPE is declared excess. If parts are available, and the desired retention level for that particular DIPEC category exceeds the equipment on hand, the add model applies.

ADD MODEL

The add model evaluates resource allocation decisions in terms of costs and benefits. The add model compares the cost to add with the benefit of adding (called the cost to not add) IPE offered to DIPEC. An item is retained when benefits exceed costs; otherwise, it is disposed of on the open market.

Cost to Add

The cost to add is the sum of one-time costs and recurring costs. One-time costs to add consist of the following:

- Administrative cost of decision making

- Packing, crating, handling, transportation, and receipt costs to move an item to a storage site

- Repair cost to make the item serviceable when it is requested for use.

The largest and hence most important element is the repair cost.

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[1] A detailed description and analysis of the economic benefit/cost model used by DIPEC is contained in Appendix A of this report.

When a Service declares an item excess, it may furnish an estimate of cost to repair the IPE. If an estimate is not furnished, DIPEC makes its own estimate based on historical data by equipment class. Repair costs vary from 10 percent to 21 percent of an item's original acquisition cost.

Recurring costs are certain annual costs multiplied by the number of years that an item of IPE is expected to be in inventory at the current rate of demand (in theory, an item will not be in inventory for more than six years, the period over which reutilization requirements are determined). These recurring costs are storage cost, management cost, and opportunity cost, representing the Government's cost of money tied up in inventory. They are relatively insignificant and have little effect on the model's outcome.

Benefit of Adding

The benefit of having an item on hand is really the cost avoided by not having to purchase a comparable item at today's current cost. It is referred to by DIPEC as the "cost to not add" and is defined as the sum of three one-time costs:

- Net disposal value
- Procurement administrative cost
- Current value of the item.

Net disposal value is calculated by averaging the Government auction prices of previously excessed equipment by class and deducting selling expenses. Disposal values range from about 4 percent to 29 percent of the item's original acquisition cost. Net disposal value is a negative benefit, because it represents the benefit foregone if the item is kept rather than sold. The procurement administrative cost represents the supervisory and clerical costs to procure a new item; it is currently set at $218 per item.

The main element of the benefit side of the equation is the item's current value in repaired condition. This value is actually the product of two others: replacement cost and technical value. Replacement cost in this context is replacement cost of a new piece of machinery that is most like the older piece of IPE. The evaluators at DIPEC now use machine tool catalogs and price lists to try to match the older equipment. As the preferred method of obtaining a replacement cost, this is successfully employed approximately 55 percent of the time. If the evaluator is unable to match the older IPE with a similar new cataloged item, he obtains a replacement cost artificially by multiplying the original acquisition cost by an annual inflation escalation factor.

Since the replacement cost is a replacement cost for new equipment that may have significantly different capabilities and, surely, longer service life than an older item, this cost must be adjusted to reflect the capabilities of the older machine. This adjustment is accomplished by assigning to the older machine a percentage called technical value. Technical value represents the relative percentage equivalence of the old machine to a new, similar machine. Technical value is calculated by assigning points for different machine characteristics: 20 points for age, 20 points for parts availability, 45 points for various design characteristics that relate to performance, and 15 points for other considerations. A perfect score is 1.00, which implies that the old machine is equivalent to a new one. A score of 50 percent gives a current value of one-half of current replacement costs, and so on.

A summary of the model's elements are presented in Table 2-1. A more detailed discussion of values for each element is contained in Appendix A.

TABLE 2-1. SUMMARY OF MODEL ELEMENTS

COST TO ADD	BENEFIT OF ADDING

- One-time costs
  -- Administrative
  -- Packing, crating, handling,
     transportation, and receipt
  -- Repair
 	
- Recurring costs
  -- Annual storage
  -- Annual management
  -- Annual opportunity
	- One-time benefits
	  -- Net disposal value
	  -- Procurement administrative
	     cost
	  -- Current value

The model contains two other elements which are not used by DIPEC in practice: costs of delay in repairing an item on the cost side of the equation and costs of delay in buying an item on the benefit side of the equation. These two costs tend to offset one another. There is no simple, practical way for DIPEC to estimate these two changing, future delay costs.

When the model is run, the result is a comparison of costs and benefits to add the item to the General Reserve. If the cost to add exceeds the benefits of adding, the model will instruct the evaluator not to retain the item. The evaluator may overrule the model but must state his reasons.

If the model produces a cost to add that is lower than the benefit of adding, one might assume that the model would instruct the evaluator to retain the IPE. There are, however, two instances in which the mathematical results of the model will be arbitrarily overridden: when the assigned technical value is lower than 45 percent, or when the age exceeds 33 years (the age cutoff is 15 years for measuring and test equipment). These overrides will cause the model to choose disposal because of age or technical value, regardless of the cost-benefit comparison. Again, the evaluator has the option of ignoring the model's decision, if he states his reason for so doing.

3. FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

REQUIREMENTS DETERMINATION

DIPEC's application of the Retention Evaluation System (RES) is dictated by the purpose for adding an item to the General Reserve -- to meet mobilization requirements, reutilization requirements, or both. The origin and validity of these requirements must therefore be scrutinized.

Improve Determination of Mobilization Requirements

The General Reserve level needed to satisfy mobilization requirements is found by DIPEC as the difference between the amount of IPE in active use in a peak year, 1968, of the Vietnam War and the amount now in active use. DIPEC uses the peak active inventory for the Federal Supply Class (FSC) to which the category of equipment belongs. DIPEC then presumes that any deficit between 1968 active inventory and today's active inventory is shared evenly for all categories of equipment in that FSC.

This procedure has several deficiencies. Active IPE inventory does not reflect privately owned machinery in use. Output requirements today may not be similar to those of 15 years ago. To the extent that active Government-owned inventory has subsequently been shifted to standby plant equipment package status, it is not counted in today's General Reserve. Finally, a deficit in an FSC is not distributed evenly to all categories of equipment belonging to the FSC.

Recommendation 1. Short of a thorough DoD-wide determination of mobilization requirements, DIPEC should correct certain deficiencies in its mobilization requirements determination. This should be accomplished by:

- Computing requirements on the basis of inventory levels specific to more detailed categories of equipment rather than by FSC (see Recommendation 3 below).

- Computing the required General Reserve level as the difference between the peak inventory of active items and the inventory in active and plant equipment package (PEP) status today (t); that is:

$$\text{General Mobilization Requirement}_t = (\text{Active})_{1968} - (\text{Active} + \text{PEP})_t.$$

Improve Determination of Reutilization Requirements

DIPEC computes reutilization requirements solely on the basis of the level of requisitions (i.e., demands) it receives.

Since DIPEC's only source of supply is used items of industrial plant equipment declared excess by a user (i.e., returns), the ability to reach the desired inventory level clearly depends on the number of acceptable returns it receives in comparison to demands satisfied. The inventory level can be increased to the desired level only when acceptable returns exceed demands satisfied.

Recommendation 2. Develop an analytical model to compute reutilization requirements more accurately. This model should reflect the following factors:

- Demands received by DIPEC from users

- Returns to DIPEC from users

- Need for multiple items of inventory to satisfy a demand because of the lack of interchangeability among items managed as a single category of equipment.

A proposed methodology for developing this model is set forth in Appendix B.

Manage IPE by More Detailed Categories of Equipment

DIPEC manages requirements by categories of equipment at a relatively high level of aggregation -- known as Interchangeability and Substitutability (I&S) Families. Thus, retention levels, inventory, and demands are set and tracked by I&S Family. An I&S Family is composed of many types of items that are not necessarily interchangeable or substitutable from the user's point of view. Even though DIPEC has an item in inventory in an I&S

Family, it cannot automatically ensure that a demand for an item belonging to that Family will be satisfied. The item in inventory may not coincide closely enough to the user's requirement. Consequently, annual demands for an I&S Family may exceed returns; yet, DIPEC's inventory level may increase because these demands remain unsatisfied. What appears to be adequate inventory to satisfy the level of annual demands may result in substantially less than this level of reissues.

Recommendation 3. Manage IPE by Plant Equipment Center number rather than by I&S Family. A Plant Equipment Center number is a 12-digit number currently used by DIPEC that identifies a machine with a high degree of specificity, ensuring that machinery within each Plant Equipment Center number is much more likely to be interchangeable. Using this means of identification will enable DIPEC to determine reutilization requirements and manage reserves more effectively. An ancillary benefit will be a more accurate compilation of data within each category to allow for determination of repair cost, packing, crating, handling, transportation, and receipt costs, and other costs that are now artificially derived.
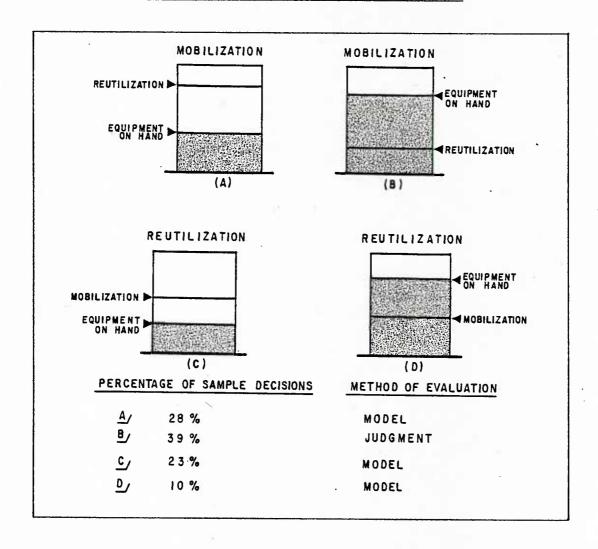
CHOICE OF RETENTION EVALUATION SYSTEM METHOD

Use Economic Model for Reutilization Requirements Only

The choice of method used by DIPEC to make retention decisions can be categorized into four possible cases. These cases are based on the relationship between mobilization and reutilization requirements and the amount of equipment on hand for the category to which an item belongs.

If the mobilization requirement exceeds the reutilization requirement, two possible cases exist:

- Equipment on hand is below both requirement levels -- this occurs in approximately 28 percent of decisions examined and is represented by diagram A in Figure 3-1.

- Equipment on hand exceeds the reutilization requirement but falls short of the mobilization requirement -- 39 percent of equipment offered is in this case, depicted as diagram B in Figure 3-1.

FIGURE 3-1.   RELATIONSHIP OF REQUIREMENTS AND
EQUIPMENT ON HAND TO DECISION FRAMEWORK

When the reutilization requirement exceeds the mobilization requirement, two possibilities also exist:

- Neither requirement is satisfied by equipment on hand -- 23 percent of IPE is in this case, represented by diagram C in Figure 3-1.

- The mobilization requirement is satisfied but the reutilization requirement is not -- 10 percent of the decisions are in this case, represented by diagram D in Figure 3-1.

DIPEC applies its economic model to evaluate cases A, B, and D. In the case in which the mobilization requirement exceeds the reutilization requirement and the reutilization requirement is satisfied (Case B), the retention/disposition decision is made judgmentally.

The choice of retention evaluation method is clear in cases B and D. In case B, the next item that is offered is evaluated for satisfaction of a mobilization requirement only and, as such, is subjected to a judgmental evaluation. Conversely, an item offered in case D is for reutilization only, and the application of the DIPEC model to perform an economic evaluation is clearly appropriate. The similarity between these two cases is that, in both, one requirement has been satisfied and the next item offered is evaluated in terms of only the other requirement.

Cases A and C also are similar. In each, the equipment on hand is below both the mobilization and reutilization requirements. Consequently, the next item of IPE offered is being evaluated for satisfaction of both requirements. DIPEC treats these two cases (which comprise over 50 percent of all items offered) as if they were offered for reutilization and applies its economic model.

Recommendation 4. Use of the economic model should be confined to those cases in which the addition of the next item is for reutilization only (Case D). If the next item of IPE is offered for satisfaction of (1) a mobilization requirement only or (2) both a mobilization and a reutilization requirement, the retention evaluation should be made judgmentally. The primary role of DIPEC is to maintain an adequate mobilization reserve. Reutilization of IPE is a secondary goal. When a piece of IPE is offered in a category in which not enough equipment is on hand to satisfy the mobilization requirement, that equipment should be evaluated according to the established

mobilization evaluation criteria (i.e., judgmentally). The fact that the reutilization requirement has also not been satisfied is irrelevant. At present the model is applied to 61 percent of IPE offered to DIPEC, but if it were applied to decisions for reutilization only, it would be applied to only 10 percent of the total cases.

ECONOMIC BENEFIT/COST MODEL

The benefit/cost model used by DIPEC is, with minor exceptions, conceptually sound. Nevertheless, inherent weaknesses in the values employed in the model bias the final results. Because of the values used in the model, application of the economic model will almost always call for retention. The dollar benefits of adding an item will usually exceed the costs, and the model will indicate retention on purely economic grounds. This tendency is especially prevalent for older machines. The phenomenon occurs essentially because current value on the benefit side of the economic model, when derived indirectly, expands geometrically with the age of an item of IPE. The other variables are either constant values or are percentages of the item's original acquisition cost. Consequently, it is virtually impossible for the economic model to indicate a disposal decision. Using DIPEC's method of assigning values, and using the largest possible values for economic cost and the smallest possible values for economic benefit, the model will indicate a retention decision. Appendix A formally demonstrates this conclusion (see pages A-13 and A-14).

In practice, non-economic criteria based on technical value and/or age usually override the economic results. After the model has been computed, the final result is expressed in terms of cost to add as opposed to benefit of adding. To adjust for the model's bias toward retention, DIPEC has established arbitrary cutoffs for age and technical value that override the model's

results. Further, the evaluator may override either the model's economic decision or the arbitrary cutoffs.

Age alone disqualifies an item of IPE if it is over 33 years old. Certain measuring and test equipment is automatically disqualified when it is over 12 years of age. In addition to the age cutoff, all IPE is disposed of if its assigned technical value score is less than 45 percent.

The LMI sample consisted of over 300 random decision cases. Table 3-1 summarizes the composition of these decisions. (Appendix C provides a detailed explanation of this sample and its results.) In making these decisions, the economic model was utilized on 178 occasions. On the basis of economic results alone, the model called for retention in 134 instances (75 percent) and for disposal 44 times (25 percent). Of the 134 model-generated retention decisions, 92 were subsequently overridden and the item excessed. Most of these overrides (70) were for technical value and/or age, with some (22) at the discretion of the evaluator. For the remaining 44 decisions in which the model called for disposing of the item, the age and technical overrides would have eliminated 42. In fact, the dominance of the arbitrary and discretionary overrides is so complete that, if they alone had

TABLE 3-1. COMPOSITION OF DECISION SAMPLE

PURPOSE	NUMBER OF DECISIONS
Total Sample	313
Decisions Discarded	23
Total Number of Decisions For Analysis	290
Judgmental Decisions to Meet Mob. Reqts. Only	112
Decisions Where Economic Model Utilized	178
Economic Model Calls for Retention (92 Subsequently Overridden)	134
Economic Model Calls For Disposal	44

been applied, without use of the model, our sample indicates that virtually the same final retention decision would have been made. We therefore conclude that DIPEC is not actually using an economic framework for its retention decisions but is basing retention on arbitrary non-economic criteria.

Base Economic Model on Fair Market Value

The largest and hence most important value in the computation of economic benefits is "current value." DIPEC usually employs an indirect method to determine current value for an item of IPE. In theory, current value is meant to reflect the value to DIPEC of having the item of IPE and not having to purchase a new or equivalent used one. It is found by multiplying current replacement cost for a similar new machine by technical value assigned to the item under consideration for addition to the General Reserve.

Replacement cost is now generally found on the basis of manufacturer's quotations or catalog prices. When such quotations are not available, DIPEC reverts to its old method of estimating replacement cost by using inflation escalation factors (about 45 percent of the time). We have found that, with the exception of measuring and test equipment, catalog costs are 65 percent to 85 percent of replacement costs found using the inflation-factor method. DIPEC's inflation factor appears high, leading to high replacement costs.

Technical value is computed by assigning points to the item on the basis of remaining service life, availability of parts, design characteristics, and other factors. Points for each characteristic are additive; e.g., a maximum of 20 points for remaining service life. Thus, an item near the end of its service life would lose, at most, 20 points out 100 points, despite the fact that it is admittedly at the end of its usefulness.

Points for design characteristics are based on detailed features for different types of equipment. A handbook has been developed for this purpose. However, the point score assigned to each characteristic is arbitrary. For example, spindle diameter is a characteristic used to rate design features of boring machines. There appears to be little basis to assign 10 points of technical value to machines with spindle diameters under three inches and 15 points to those with spindle diameters of three inches or more.

The assignment of technical value by DIPEC should be significantly influenced by age of the item. Age accounts for 20 out of 100 points of technical value, while characteristics of design and parts availability should clearly be age-related. An analysis (see pages A-10 and A-11) of assigned technical value and an item's age indicated, in certain instances (e.g., Metal Cutting and Forming Machines), that age plays little or no statistically significant role in technical score. For General Purpose and Measuring/Test Equipment, age played a role but explained less than one-half of the variation in score among machines sampled.

There is an alternative method, superior to the artificial method employed by DIPEC, for establishing current value. The only method that has proven effective in establishing value is the free market. A fair market value is a price that results from the interaction of many independent buyers and sellers who are skilled at evaluating an item's value in comparison to others available, including new machines. Fair market value reflects the market's assessment of a used item's remaining service life, productivity, and operating costs relative to other new and used machines.

The implication of using fair market value in place of DIPEC current value goes beyond merely replacing a number in the economic benefit/cost calculation. There is an intrinsic relationship between repair cost, disposal

value, and fair market value that has a major implication for retention decisions. "Current value" and "disposal value" have special meanings as used in the economic evaluation model. Current value represents the value of the item in good working condition. Thus, fair market value, if used instead of DIPEC's current value, is fair market value of an item in good working condition. Disposal value represents what the item would return if sold in the open market in its current (unrepaired) condition. Consequently, what the item would sell for in current condition (disposal value), plus the cost to repair the item to bring it to good working condition should, in theory, coincide with the fair market value of the item in good working condition. If the item is in good working condition and needs no repair, fair market value should coincide with disposal value. If the item costs more to repair than the fair market value of similar items in good repair, its disposal value would be virtually zero (or scrap value). Thus, there is a clear linkage between disposal value, repair costs, and fair market value:

> Fair Market Value = Disposal Value + Repair Costs;
> provided Repair Costs are less than Fair Market Value.

This linkage has implications for the economic evaluation conducted by DIPEC and the decision rules that result from the economic model. The economic model compares repair cost to DIPEC's current value less disposal return. In addition, other minor costs (storage, administrative, and packing, crating, handling, transportation, and receipt costs) are compared to the administrative costs of procuring a new item. If fair market value is used instead of current value, the economic formula would reduce to a consideration of repair costs and fair market value of the item in good condition. An item would be retained if repair costs are less than fair market value.

Recommendation 5. DIPEC should base the economic model used for items considered for reutilization on fair market value of the item and not

DIPEC's artificial "current value." Use of fair market value reduces deci-sions to a comparison of (1) cost to repair an item to bring it to good working condition with (2) the item's fair market value in good working condi-tion. Items should be retained only when repair costs are less than fair market value. The considerations remaining in the economic model are essen-tially comparisons of administrative costs of storing an item as opposed to the administrative costs of reprocuring it at a later date. These costs are relatively small constants and do not have to be used to make retention decision for individual items.

Use Independent Appraisers to Estimate Fair Market Value

If DIPEC bases its retention evaluation on a comparison of cost to repair versus fair market value of that machine in good working order, accu-rate values must be used. An item's repair cost is either estimated by the user or estimated by DIPEC on the basis of historical data compiled by FSC. The problem with estimating repair cost from historical data is twofold. First, because of the large variance in actual repair costs based on the condition of the item, an average repair cost is not a valid value to employ for making a decision for any one machine. Secondly, the first problem is compounded by the level of aggregation of the historical data. Equipment contained in an FSC is much less homogeneous than that contained in DIPEC's I&S Families. Therefore, not only is there the error connected with averaging a wide variance of repair costs and applying this average repair cost to one machine, but also the average itself is not a good one, since it applies to too many categories of equipment. Repair cost should be derived, by qualified personnel, for an individual machine on the basis of its condition and the availability of parts.

The method for determining fair market value of an item is not as clear. No national compilation of data exists that an evaluator may rely on to provide an average price for each machine. This lack of a used-equipment price catalog (i.e., a blue book) is caused by the almost infinite variety of types of accessories and quality of machines and by the fact that the price of any one machine varies widely in relationship to its condition. Attempts have been made to compile a "blue book" for used machinery, but these were never successful. The closest approximation is the "Machinery Market Bulletin" published by the Machinery Dealers National Association. It contains nation-wide auction reports that set forth IPE sold and its sale price. It has been estimated that this report includes approximately 40 percent of major auction results. However, this information is presented auction by auction. The data are not organized in a fashion that vendors find useful.

Recommendation 6. DIPEC should employ independent appraisers to obtain accurate estimates of repair costs and fair market value. Even assuming that DIPEC succeeded in organizing historical data in a "blue book" format and establishing a fair market value for a machine in good working order, for each type of machine evaluated, repair cost is not susceptible of derivation in this manner. An independent appraiser would be capable of estimating both values. At present, if DIPEC decides not to retain an item, it has it shipped to the nearest storage site for eventual disposal by auction. Therefore, there would be virtually no increased cost to DIPEC to ship all items to these sites prior to evaluating them for retention. When a certain number of machines have collected at one location, they could be examined by an appraiser. This system would minimize the cost to the Government of conduct-ing these appraisals. The appraiser should be instructed to estimate the fair market value of that machine in good working condition in an average market.

The market price of certain types of IPE can fluctuate widely in response to the business cycle. The market for many of these machines is very thin, and a national increase of production of certain goods could cause prices of some IPE to skyrocket. This should be taken into account when any appraisal is accomplished.

Any appraiser employed by DIPEC should be independent. This independence is critical to maintaining an objective standard. Even more important is the fact that an independent appraiser is familiar on a day-to-day basis with public market and auctions results that are fundamental in determining fair market value.

USER CHARGES

Charge Users to Cover Repair and Reissue Costs

Under current procedures, DIPEC provides users items of IPE, with DIPEC bearing the cost of handling, administration, storage, and, most importantly, repair. In fact, an item is stored by DIPEC in its current condition until it is requisitioned by a user. Repair is made at the time of issue.

Users of DIPEC inventory thus face a choice of acquiring a new item at today's current acquisition price, compared to a used item from DIPEC at what amounts to zero price. Thus, the user's choice is biased towards no-cost DIPEC inventory in comparison to fully market-priced new equipment. The real cost of providing a used item to DoD is, however, not zero. All the costs borne by DIPEC to handle, store, and repair an item are real costs to DoD that are not incurred by the user. The user would make different decisions if confronted with the true costs associated with his alternatives. In fact, the user would no longer treat items acquired from DIPEC as free goods and would be forced to make economic tradeoffs between the value of used and new equipment, considering service life, productivity, and cost.

Recommendation 7. DIPEC should charge users for issues of items of IPE at rates that accurately reflect DIPEC's cost of handling, transporting, storing, and, most significantly, repairing the item. DIPEC's revenues should not be expected to cover its total annual operating costs, since much of its activity would not be reimbursable. What really matters is that user charges for reutilized IPE should accurately reflect costs associated with reutilization.

APPENDIX A

ANALYSIS OF ECONOMIC BENEFIT/COST MODEL

INTRODUCTION

The economic evaluation conducted by the Defense Industrial Plant Equipment Center (DIPEC) seeks to compare the cost of adding and holding in the General Reserve an offered item of industrial plant equipment (IPE) with the benefit of doing so. The benefit is, in effect, the cost avoided because acquisition of a new item by the Department of Defense (DoD) is made unnecessary. Under current DIPEC practice, an economic evaluation is conducted for items considered for addition to the General Reserve to satisfy (1) reutilization requirements or (2) both mobilization and reutilization requirements. Retention of items when reutilization is adequate and the mobilization requirement is not yet satisfied is based on non-economic factors.

In this appendix, the economic benefit/cost model is described, the numerical values used to implement it are discussed, and conclusions concerning its workings are drawn.

MODEL STRUCTURE

The model compares the cost of adding and holding an item in the General Reserve with the benefit of avoiding subsequent purchase of a new item. The factors constituting costs and benefits are described next.

Cost of Adding

The costs of adding IPE to the General Reserve are either (1) one-time costs associated with a decision to add or (2) costs that recur annually. Recurring costs are experienced each year the item is projected to stay in the inventory -- from one year to a maximum of six, since DIPEC's reutilization

requirement extends out, in theory, to six years of demand at most. One-time costs consist of --

- Administrative costs inherent in the action of personnel in the course of decision making;

- Packing, crating, handling, transportation, and receipt costs associated with moving idle equipment from its former site to a Defense Logistics Agency (DLA) storage site; and

- Repair costs to bring an item held in the General Reserve up to satisfactory working condition.

Recurring costs experienced for each year an item is held consist of --

- Storage costs for the maintenance of equipment in humidity-controlled warehouses;

- Management costs for personnel involved in the day-to-day administrative management of the General Reserve; and

- Investment (opportunity) cost representing the time-value of money that would be available to the Government if it were not tied up in inventory investment for items in the General Reserve.

Benefit of Adding

The benefit of adding equipment to the General Reserve represents the costs avoided by not having to procure a new item. Consequently, net benefits consist mainly of that portion of a new item's acquisition cost represented by an acceptable used piece of equipment. The cost avoided by having a used item is clearly not the entire cost of acquiring a new item, since the used item's remaining service life and productivity are lower. Any additional benefit of adding IPE to the inventory comes from avoiding the administrative costs associated with procuring new equipment. Finally, benefits must be reduced by the disposal value of the used item, which would be captured by the Government if the item were sold and not retained. Thus, the benefits of adding an item to the General Reserve consist of --

- Current value of the item, representing the value of the used item given its remaining service life, productivity, and replacement costs in comparison to a new item;

- Procurement administrative costs to the Government for a procurement action to acquire a new item of equipment; and

- Disposal value (a negative benefit), representing the value that otherwise would accrue to the Government had the used item been sold on the open market rather than added to the General Reserve.

The formal model also includes in its structure what are called delay penalty costs, representing costs to DoD when IPE cannot be procured or repaired on schedule. Delay costs for repair are costs associated with adding a used item to the General Reserve, while procurement delay costs are a negative benefit in the benefit-to-add calculation. No practical ways to calculate these costs are available, and they are not used in the economic evaluation.

MODEL VALUES

An item of equipment offered to DIPEC and needed to satisfy reutilization requirements is subjected to an economic evaluation, using dollar values for the elements just described. An item is added (1) if the cost of adding is less than the benefits or (2) disposed of when costs exceed benefits. Besides the economic considerations of the benefit-cost model, two other criteria are used by DIPEC in its retention decision making. The results of the benefit-cost calculation are overridden and an item is automatically excessed if the item was manufactured before 1950. This is based on an arbitrary rule that items over 33 years old will not be retained. The second overriding criterion is based on what is called technical value. Items assigned a technical value of less than 45 points are automatically excessed and, in turn, disposed of in the used equipment market. Technical value as defined by DIPEC is described more fully later in this section.

In this section we describe how DIPEC estimates each element of economic costs and benefits. These elements are ordered to correspond to the previous presentation -- one-time and then recurring annual cost elements associated

with the cost of retention, followed by elements constituting the benefits of retention.

Cost of Adding

Administrative Costs. Administrative costs are determined by taking job standards for various activities associated with administration and applying current hourly rates to give dollar costs. Activities included come from internal cost accounts and cover 12 functions ranging from processing initial reports to storage and distribution management. In addition to basic hourly rates for personnel assigned to each function, a leave factor of 20 percent and fringe benefits of 18.1 percent are added. Materials and supplies are also factored in, on the basis of the historical ratio of these costs to total personnel costs. DIPEC is now using a total cost for administration of $20.26 for adding an item to its inventory. This figure is based on labor rates for October 1979 and is in need of upward revision. In addition, an arbitrary reduction appears to have been applied to the cost value to reflect DIPEC activities other than administering the General Reserve.

Packing, Crating, Handling, Transportation, and Receipt (PCHTR) Costs. These costs are those associated with moving an item to DLA storage. DIPEC uses a dollar value specific to the machine in question when such a value is known. The value will have been estimated in the field on Form DD 1342. In the absence of specific information, DIPEC factors in these costs on the basis of historical experience. They are expressed as a percentage of the item's original acquisition cost and average around 6 percent in practice. Thus, machines that are identical but of differing vintages and hence differing original acquisition costs will not have the same PCHTR costs. It would appear more suitable to estimate these costs as a fixed value for the packing, crating, handling, and receipt components and a variable cost for the

transportation component based on weight (a known factor) and distance to the DLA storage site.

Repair Costs. Repair costs are the most important one-time costs associated with the decision to add an item to the General Reserve. They play an even more critical role if fair market value is used instead of the "current value" now used by DIPEC. An item's repair cost is either estimated by the current user upon submission of DD Form 1342 or, more typically, is estimated by DIPEC on the basis of historical experience for the item's Federal Supply Class (FSC). This means that the repair cost entered into the cost portion of the economic evaluation for a particular item is based on the average experience for the item's entire FSC. Repair costs are expressed as a percentage of the item's actual original acquisition cost, which is available to DIPEC by each item's identification number. Repair-cost percentages range from a low of 6 percent of original cost for FSC 3408 to a high of 35 percent for FSC 3410.

A deficiency of DIPEC's uniform percentage method for each four-digit FSC is that no consideration is given to the condition of the specific item under consideration. An item's repair cost is judged on the basis of experience with other items in its class independent of age, condition, hours of use, and other potentially relevant factors. Such factors could be considered through the application of statistical analysis of data available to DIPEC. As items are repaired in the future, DIPEC could track not only repair cost and original acquisition prices but also age, condition code, and other factors. Statistical analysis could then identify (1) whether or not these factors influence repair cost and (2) the overall suitability of an estimated approach to ascertain repair costs. If DIPEC follows the recommended approach of using fair market value in the economic benefit calculation, even more

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item-specific quantification of repair costs beyond what could potentially be obtained from estimation would be advisable. Thus, inspection and repair estimation by knowledgeable experts for each item would be required.

Annual Storage Costs. Annual storage costs are based on the particular item's space requirement, multiplied by a factor representing the cost per square foot to warehouse the item in a controlled-humidity environment. Required square footage is taken from the item's historic record, where length and width in feet are maintained. Warehouse cost, 73 cents per square foot, is obtained from DoD 4145.19-R, "Storage and Warehousing Facilities and Services." This unit cost figure was computed in 1979 and has not subsequently been updated. Since storage is an annual cost, it is calculated for the number of years DIPEC projects the item to be held in its inventory. In theory, storage will not exceed six years' duration, since this represents the maximum time inventory is maintained for reutilization purposes. In practice, inventory is likely to be held longer, since requisitions are unlikely to be met despite inventory availability (see our discussion in Appendix B on reutilization requirements).

Annual Management Costs. Annual management costs are a fixed annual charge applied to the anticipated number of years of retention. The annual cost is obtained from cost accounts for six activities associated with inventory management, using the same procedure followed to obtain administrative costs. The annual cost now used, $5.66 per year, is based on job standards and hourly rates applicable in 1979.

Annual Opportunity Cost. Annual opportunity cost is an imputed cost representing the value to the Government of the funds invested in General Reserve inventory. When an item is not retained, the Government recoups the salvage value of the item through an open-market sale. Retention thus has an

imputed cost representing what the Government would earn on the disposal proceeds. Office of Management and Budget guidance suggests a 10-percent rate as representative of the time value of money to the Government. Consequently, a 10-percent-per-year factor is applied to the salvage value of the item. Salvage value, called disposal return by DIPEC, is based on average experience for each FSC class. It is expressed as a percentage of the item's original acquisition cost.

Benefit of Adding

The three elements constituting the benefits of retaining a used item of equipment in the General Reserve are current value, procurement administrative costs, and disposal value. Current value represents that portion of the costs avoided (through availability of a used item) that would be incurred in the purchase of a new item. It is the most important and most controversial element in the economic evaluation. Procurement administrative costs are those involved in procuring a new item that are avoided when a used item is available from DIPEC. Disposal or salvage value is a negative benefit (i.e., a cost that could be shown under the cost side of the evaluation). Each of these elements is discussed next.

Current Value. Current value is the most critical and controversial element in the benefit calculation and indeed in the entire benefit/cost evaluation. It represents the cost avoided by having a used item available for reutilization and, consequently, by not having to procure a new item. DIPEC's method for estimating current value is based on an internal procedure consisting of two parts: first, ascertainment of current replacement cost for a new item and, second, the development of a percentage (called technical value) that is a representation of the remaining percentage value of the used item in comparison to a new one. Thus, an item being considered for retention

that is virtually equivalent to a new item would have a technical value of 100 percent. Its current value would be 100 percent of the acquisition cost or the equivalent of the replacement cost of a new item. An item rated at one-half the equivalent of a new item would be assigned a current value of 50 percent of the current cost of a new item, and so on.

DIPEC determines current replacement cost in one of two ways. The item's original acquisition cost is inflated by a DIPEC-generated inflation rate of 6.68 percent per year. For equipment falling into Group 4, Measuring and Test Equipment, the inflation factor is 2.17 percent. Use of these factors was until recently the exclusive procedure for determining current replacement cost. Now, DIPEC obtains current price quotations from manufacturers when similar equipment is still being produced. This change in procedure stems from criticism of the inflation rates used by DIPEC. An examination of machinery and equipment price indices published by the Bureau of Labor Statistics indicates an annual inflation rate of about 4.5 percent for a period comparable to that covered by DIPEC's replacement cost factor table.

This seemingly small difference in inflation rates can have significant impact for equipment manufactured 25 to 35 years ago -- typical of items offered to DIPEC. An item manufactured 25 years ago would have an estimated replacement cost of three times its original cost with a 4.5-percent growth rate, but the replacement cost would be five times original cost with a 6.68-percent growth rate. A review of recent decisions by DIPEC indicates that DIPEC is now obtaining current replacement cost quotations about 55 percent of the time. For the remainder of decisions, the equipment is no longer manufactured and the growth factor approach is used.

A comparison was made between actual replacement cost quotations now used by DIPEC in 55 percent of its decisions and the results obtained by using

its inflation growth factor. Generally, a substantial reduction from the inflation factor approach was found when actual quotations were obtained. Table A-1 displays the percentage difference between actual cost quotations and the replacement cost that would have been generated had DIPEC's inflation growth factor method been used.

TABLE A-1. PERCENTAGE DIFFERENCE BETWEEN PRICE QUOTATIONS AND DIPEC'S INFLATION FACTOR METHOD BY MAJOR COMMODITY GROUPS

GROUP	PERCENTAGE DIFFERENCE	NUMBER OF OBSERVATIONS
1. Metal Cutting Machinery	-30%	121
2. Metal Forming Machinery	-35%	26
3. General Purpose Machinery	-15%	6
4. Measuring and Test Equipment	+12%	3
		TOTAL 156

Once current replacement cost is estimated, DIPEC assigns its technical value percentage. The product of current replacement cost and technical value percentage yields the current value used to measure the benefit of adding and holding the item in the General Reserve.

Technical value is computed by assigning points to the item on the basis of remaining service life, the availability of parts, technical design characteristics, and other factors. Points for each of these characteristics are additive: a maximum 20 points for remaining service life, 20 points for availability of parts, 45 points for design characteristics, and 15 points for other factors. This means that an item near the end of its expected service life would lose at most 20 points out of 100 possible, despite the fact that it is admittedly at the end of its usefulness.

Points for design characteristics are based on detailed characteristics for different types of equipment. Technical value sheets for design features are contained in DIPEC 4140.1, "IPE Quality of Design." This source lists design features for items and associated assigned points for each feature, up to a maximum of 45. By way of illustration, ratings for boring machines (jig, horizontal) are based on method of operation, spindle speed, table feeds, and spindle diameter. Radial-floor-type drilling machines are rated on column diameter, arm bearing, arm elevation method, and quantity of speeds and feeds. It is evident that design features associated with machine type are reasonable representations of machine characteristics and that the progression of technology over time increases machine capability measured by these characteristics. However, the point score assigned to each characteristic is arbitrary. For example, spindle diameter is a characteristic used to rate boring machines as mentioned above. But there appears to be little basis to assign 10 out of a total of 45 points to machines with spindle diameters under three inches and 15 out of 45 points to those with spindle diameters of three inches or more.

The assignment of technical value by DIPEC should be significantly influenced by age of the item. Age, per se, accounts for 20 percent of the overall score. Design characteristics should reflect the progression of technology and be age-related. Automatic versus manual operation and increasing speeds and feeds should correlate with vintage of equipment. Availability of parts should clearly be age-related. To test this hypothesis, a statistical analysis of the effect of age on assigned technical value was conducted. The expectation was that technical value would decline with the age of the machine and that age would explain most of the assignment of technical value. But this expectation proved incorrect in certain instances. Table A-2

presents the results of statistical regression analysis examining the relationship of age to technical value.

TABLE A-2. <u>ANALYSIS OF TECHNICAL VALUE AND AGE</u>

EQUIPMENT GROUP	INTERCEPT	SLOPE	t-VALUE$_1$	R^2_1	NUMBER OF OBSERVATIONS	OBSERVED AVERAGE AGE
1. Metal Cutting	70	-0.66	-4.9	0.25	74	26.6
2. Metal Forming	19	+0.8	+1.6	0.1	23	24
3. General Purpose	75	-2.1	-4.2	0.5	19	16.4
4. Measurement & Test	71.5	-3.0	-4.2	0.44	24	34.9

The results in Table A-2 indicate that, for metal-cutting machinery, technical value declines from a base value of 70 points at a rate of 0.66 point for each year of age of the machine. Age is a significant determinant of technical value (as indicated by a t-value over two in absolute value), but age accounts for only 25 percent of the variation in technical value observed in the sample. Despite the fact that age directly accounts for 20 out of 100 points in technical value, and that design considerations and parts availability should be related indirectly to age, we see that only 25 percent of technical value is explained by age. For metal-forming machinery, results in Table A-2 indicate that age plays no statistically significant role in DIPEC's assignment of technical value. For the remaining two categories, age is statistically significant and explains 45 to 50 percent of the technical value.

<u>Procurement Administrative Costs</u>. Procurement administrative costs are treated as a constant factor of $218.24 per item. This figure was provided to DIPEC by DLA on the basis of the average experience of four DLA purchasing activities. The figure is for 1979 and includes leave and fringe

benefit factors but does not include cost estimates for transportation from the manufacturer to the ultimate user.

Disposal Value: Disposal value is the net value that would be captured by the Government from selling the item on the open market. This value appears as a negative benefit of adding and mathematically and conceptually could be treated as a positive cost on the "cost-to-add" side of the economic model. It is a negative benefit (i.e., cost) because it represents what would have been salvaged had the item not been retained by DIPEC. The disposal value is calculated as a percentage of original acquisition cost based on experience from the most recent year's disposal activity. Disposal percentage factors are for the four-digit FSC class to which the item belongs.

WORKINGS OF MODEL

The structure of the Retention Evaluation System economic model is sound in principle -- it considers all costs and benefit elements associated with adding an item to the General Reserve. The single analytical objection that can be raised involves timing of costs and benefits. The model does not consider discounting for the time value of money to the Government. Costs and benefits incurred in distant years are given the same weights as costs and benefits in more immediate years.

Structural soundness, however, does not imply that implementation of the model using the numerical estimates employed by DIPEC is also sound. In fact, the model will usually result in a retain decision unless overridden by technical value or age considerations. The costs to add are usually less than the benefits of adding. The model is then often overridden by non-economic criteria -- age over 33 years and/or technical value less than 45 points.

To see why this is the case, we next examine the model to determine under what circumstances it would call for disposing of an item. The model involves a comparison of costs to add an item to the General Reserve with the benefits of adding the item. The model can be expressed in the following equation form:

Administrative Costs + PCHTR Costs + Repair Costs + (Number of Years held) x [Annual Storage Costs + Annual Opportunity Costs + Annual Management Costs]

vs

Procurement Administrative Costs - Disposal Value + Current Value.

The costs associated with adding an item and the values employed by DIPEC are as follows:

- Administrative = $20.26, a fixed value

- PCHTR = (PCHTR %) x OAC = 0.06 x (OAC), where OAC is original acquisition cost and PCHTR is found to average 6 percent

- Repair = (Repair %) x OAC = 0.21 x (OAC), where repair percentage is 21 percent at its maximum

- Annual Storage = 73¢ per square foot x length x width (in feet)

- Annual Opportunity = (10%) x (Disposal %) x OAC, where (Disposal %) is the historic percentage by FSC

- Annual Management = $5.00, a fixed value.

To see why the model is biased in implementation toward retain decisions, we next use values that make the cost to add the largest possible amount. These values come from factors used by DIPEC or are derived from sample findings. To accomplish this, we set (Repair %) at the maximum found for any group -- 21 percent. We also set storage at the maximum annual value of $76 an item, and (Disposal %) at .18, the average of all FSCs. Finally, we use the maximum

number of years an item can be held in storage (six years) to convert annual cost elements to their (maximum) total costs. This gives cost to add as:

$\cdot$ (1) Cost to Add = $510.22 + 0.378 x (OAC).

The benefit of adding consists of the following:

- Procurement Administrative Costs = $218, a fixed cost

- Minus Disposal Value = -(Disposal %) x OAC = -(.18) x OAC

- Current Value = (Replacement Cost) x (T.V.), where replacement cost is the (Growth Factor) x (OAC) and T.V. is technical value.

For a 33-year-old machine, the growth factor is 9.06; that is, replacement value grows to 9.06 times original cost at DIPEC's 6.68 annual percent growth rate. Comparing cost with benefit, we then see that benefit always exceeds cost (i.e., the decision is retain) as long as original cost exceeds $83. In fact, original acquisition costs for offered items to DIPEC average in excess of $23,000. Thus, an item as old as 33 years will almost certainly generate a retain decision (benefit exceeding cost), provided it is assigned a technical value over 45 points and thus is not automatically excessed.

APPENDIX B

METHODOLOGY TO DETERMINE REUTILIZATION REQUIREMENT

The first part of this Appendix is applicable to calculating a reutiliza-
tion requirement if DIPEC changes its level of management to Plant Equipment
Center (PEC) number as recommended. The latter portion provides a method for
adjusting this requirement for the lack of homogeneity within each Inter-
changeability and Substitutability (I&S) Family. This latter section should
be used if DIPEC elects not to change its system, or it could be implemented,
prior to any change, for the interim period.

DIPEC maintains historical information by quarter on demands, returns,
disposals, and inventory. These data are called the Requirements Forecast I&S
Family and Summary (DIPEC Report RCS-DIPEC-SS-68) and are by I&S Family. They
are maintained for the latest three years (12 quarters). This data base
provides the information necessary to calculate reutilization requirements
reflecting (1) demands received by DIPEC from users, (2) returns to DIPEC by
users, and (3) DIPEC's inability to always satisfy a demand from available
inventory. These considerations are illustrated with data taken from the
above-mentioned report for a prevalent I&S Family, Manual Engine Lathes
(3416BA). In Table B-1 we list quarterly demands, accepted returns, issues,
and inventory levels. Using these data, we first construct the stock level of
inventory necessary to satisfy a specified fill rate. Fill rate represents
the percentage of demands that can be satisfied by a given stock level. In
this first step, we assume that an item of inventory, if available, will
satisfy a demand. The second step is an adjustment to account for the fact
that, since items in an I&S Family are not all alike, many are generally
required to ensure that a demand can be satisfied.

B-1

TABLE B-1. <u>REQUIREMENTS FORECAST DATA FOR I&S FAMILY 3416BA</u>:
<u>MANUAL ENGINE LATHES</u>

TIME PERIOD (FY/Quarter)	DEMANDS	ACCEPTED RETURNS	ISSUES	INVENTORY
82-4	89	18	17	950
82-3	71	20	21	950
82-2	122	20	23	949
82-1	70	28	19	948
81-4	21	30	10	957
81-3	50	45	14	973
81-2	63	20	16	1003
81-1	69	19	26	1003
80-4	44	15	14	995
80-3	90	43	26	999
80-2	92	29	24	1010
80-1	<u>48</u>	<u>15</u>	29	1009
Average	69	34		

Source: DIPEC Report RCS-DIPEC-SS-68, 30 September 1982.

To determine the stock level necessary to meet a specified fill rate, before adjustment for unlike items in an I&S Family, the following procedure is employed.

During each period there are demands from customers and returns to DIPEC. The objective is to calculate a retention level such that whenever stock on hand exceeds this level, disposal activities can be undertaken. The calculated retention level then corresponds to the reutilization requirement. The retention level must be high enough to allow for variability in the demand and return processes -- providing a high fill rate. But it should not be so high as to preclude the opportunity for disposal activities that can be profitably undertaken without degrading customer support.

The model is based on the following definitions:

   S = stock on hand now

   D = demand during a specified period T

R = returns during T

Y = stock on hand at beginning of T.

The value of S is assumed to be known. D and R are random variables whose means and variances are computed from historical data maintained by DIPEC. For the case of I&S Family 3416BA, the mean demand per quarter is 69.08 items, with a variance of 722.8. For this same I&S Family, the mean returns per quarter are 34, with a variance of 167.3. The mean value of the stock on hand during T is given by:

$$\text{Mean }(Y) = S + \text{Mean }(R) - \text{Mean }(D)$$

However, the variances of demand and returns are additive, so that:

$$\text{Variance }(Y) = \text{Variance }(R) + \text{Variance }(D)$$

Since the variances are additive, it is important to properly model the process to ensure adequate customer support.

A useful measure of system performance is the fill rate -- the percent of demands that can be met immediately. For any target fill rate over the specified time period T, the corresponding retention level, S, can be determined as follows.

Let d(i) = probability of d demands during T
    r(i) = probability of r returns during T
    F   = expected (mean) number of fills during T

$$\text{Then } F = \sum_{i=1}^{S} i\,d(i) + (S)r(0) \sum_{i=s+1}^{\infty} d(i)$$

$$+ (S+1) \left\{ d(S+1) \sum_{i=1}^{\infty} r(i) + r(1) \sum_{i=S+2}^{\infty} d(i) \right\}$$

$$+ (S+2) \left\{ d(s+2) \sum_{i=2}^{\infty} r(i) + r(2) \sum_{i=S+3}^{\infty} d(i) \right\}$$

$$+ \ldots \ldots \ldots \ldots \ldots \ldots \ldots$$

The fill rate is F divided by the mean demand, Mean (R).

The expression for the number of fills is composed of several additive terms:

- i fills if the number of demands, i, is S or less.

- S fills if the number of demands, i, is more than S and there are no returns.

- S+1 fills if the number of demands, i, is S+1 and there are 1 or more returns; or the number of demands is more than S+1 and there is exactly one return.

- S+2 fills if the number of demands, i, is S+2 and there are 1 or more returns; or the number of demands is more than S+2 and there are exactly two returns.

- Similar terms for S+3, S+4, etc., must also be evaluated.

The data for I&S Family 3416BA produces the retention levels based on associated fill rates as shown in Table B-2.

TABLE B-2. ILLUSTRATIVE RETENTION LEVELS
FOR ALTERNATIVE FILL RATES

RETENTION LEVEL	FILL RATES (%)
64	95
80	98
92	99

In some cases the actual stock on hand will be substantially below the desired target retention levels. This can happen even when expected returns exceed expected demands because of the effects of variance. Consequently, the desired retention stock level should be recalculated each period. This would incorporate the actual demands and returns from the latest period together with updated estimates of the means and variances for the probability distributions of demand and return over the next period T.

The second stage of the requirements determination involves the adjustment to account for the fact that items in an I&S Family are not alike and

that, therefore, many are generally required to ensure a fill. To accomplish this adjustment, we analyze the historical relationship between fills and inventory for the I&S Family. Table B-3 arranges the data in Table B-1 for I&S Family 3416BA so that this relationship can be inferred.

TABLE B-3. HISTORIC RELATIONSHIP BETWEEN FILL RATE AND
INVENTORY FOR I&S FAMILY 3416BA:
MANUAL ENGINE LATHES

TIME PERIOD (FY/Quarter)	FILL-RATE PERCENTAGE (Issues ÷ Demands)	INVENTORY ÷ DEMAND
4-82	19.0	10.67
3-82	29.6	13.38
2-82	18.9	7.78
1-82	17.1	13.54
4-81	47.6	45.57
3-81	28.0	19.46
2-81	25.4	15.92
1-81	37.7	14.54
4-80	31.8	21.71
3-80	28.8	11.06
2-80	26.1	10.98
1-80	39.6	21.02

It is evident from these data that the fill rate is high when there is much inventory per demand, and conversely low when demand is high in relation to inventory. For example, in the fourth quarter of FY 1981, when there were over 45 items in inventory per demand received, the fill rate was nearly 50 percent. It was in the 32-to-39 percent range when about 20 items were in inventory per demand. The lowest fill rates were recorded when inventory dropped to 8 to 12 items per demand.

To quantify this behavior, a least-squares linear regression was computed for fill rate against inventory per demand, using the data in Table B-2. Inventory per demand was capable of explaining over 68 percent of the observed

variation in fill rates. The estimated relationship is:

$$y = 18.247 + 0.6839x; \quad R^2 = .681$$

where y = fill rate (percentage)
and x = number of items in inventory per demand.

Applying this relationship to the unadjusted stock level found in the first stages gives the inventory necessary to meet a desired fill rate, considering demands, returns, and the fact that many unlike items are in an I&S Family.

A relatively simple computer program written in BASIC was developed to calculate retention levels for desired fill rates. It is reproduced below.

TABLE B-4. BASIC PROGRAM TO CALCULATE STOCK LEVEL
TO MEET VARIOUS FILL RATES

```
10 '        CALCULATE STOCK LEVEL FOR DLA SALVAGE  "MYRON"  5/2/83
20 DIM D(12,2),P(1000,2),MEAN(2),VAR(2),A(2),PO(2),N(2),STK(3),PSUM(2)
30 LPRINT "        STOCK LEVELS TO MEET VARIOUS FILL RATES"
40 LPRINT
50 LPRINT "    ****DEMANDS****   ****RETURNS****    ****FILL RATES****"
60 LPRINT " #  MEAN  VAR/MEAN  MEAN  VAR/MEAN    .95    .98    .99"
70 DATA 89,71,122,70,21,50,63,69,44,90,92,48
80 DATA 66,67,66,75,74,101,58,69,60,123,84,68
90 DATA 4,2,16,5,0,6,11,11,7,19,0,5
100 DATA 2,1,5,3,0,3,4,0,3,0,4,1
110 NMAX=1000
120 FOR M=1 TO 2:FOR J=1 TO 3:STK(J)=0:NEXT J
130 FOR J=1 TO 2
140 MEAN(J)=0:VAR(J)=0
150 FOR I=1 TO 12
160 READ D(I,J)
170 MEAN(J)=MEAN(J)+D(I,J):VAR(J)=VAR(J)+D(I,J)*D(I,J)
180 NEXT I
190 VAR(J)=(VAR(J)-MEAN(J)*MEAN(J)/12)/11:MEAN(J)=MEAN(J)/12
200 IF MEAN(J)>0 THEN VAR(J)=VAR(J)/MEAN(J) ELSE VAR(J)=0
210 IF VAR(J)<1.0001 THEN VAR(J)=1.0001
220 A(J)=MEAN(J)/(VAR(J)-1):PO(J)=(VAR(J)-1)/VAR(J)
230 '    CALCULATE PROBABILITIES OF DEMANDS (1) AND RETURNS (2)
240 FACT=(1-PO(J))^A(J)
250 FOR I=0 TO NMAX:P(I,J)=0:NEXT I:PSUM(J)=0:N(J)=NMAX:XMN=0
260 FOR I=0 TO NMAX
270 P(I,J)=FACT:PSUM(J)=PSUM(J)+P(I,J):XMN=XMN+I*P(I,J)
280 IF P(I,J)<9.999999E-06 AND I>2*MEAN(J) THEN N(J)=I:GOTO 310
290 FACT=FACT*PO(J)*(A(J)+I)/(I+1)
300 NEXT I
310 PRINT N(J),PSUM(J),MEAN(J),XMN:NEXT J
320 S1=VAR(1)*MEAN(1)+VAR(2)*MEAN(2):PRINT S1,
330 IF S1>0 THEN S1=SQR(S1) ELSE S1=0
340 S1=MEAN(1)-MEAN(2)+S1:IF S1<0 THEN S1=0 ELSE S1=INT(S1)
350 PRINT S1
360 '    CALCULATE FILL RATES
370 FOR S=S1 TO NMAX
380 PSUM(1)=P(0,1):FILLR=0
390 FOR I=1 TO S
400 FILLR=FILLR+I*P(I,1)
410 PSUM(1)=PSUM(1)+P(I,1)
420 NEXT I
430 FILLR=FILLR+S*(1-PSUM(1))*P(0,2)
440 PSUM(2)=P(0,2):K=0
450 FOR I=S+1 TO NMAX
460 K=K+1
470 PSUM(1)=PSUM(1)+P(I,1)
480 DELTA=I*(P(I,1)*(1-PSUM(2))+(1-PSUM(1))*P(K,2))
490 FILLR=FILLR+DELTA
500 IF DELTA<.00001 THEN 530
510 PSUM(2)=PSUM(2)+P(K,2)
520 NEXT I
530 FILLR=FILLR/MEAN(1):PRINT I,S,FILLR
540 IF STK(1)=0 AND FILLR>.95 THEN STK(1)=S
550 IF STK(2)=0 AND FILLR>.9799999 THEN STK(2)=S
560 IF STK(3)=0 AND FILLR>.9899999 THEN STK(3)=S:GOTO 580
570 NEXT S
580 LPRINT USING"##";M;:LPRINT USING"####.###";MEAN(1);VAR(1);MEAN(2);VAR(2);
590 LPRINT USING"    ###";STK(1);STK(2);STK(3)
600 NEXT M
610 BEEP
```

APPENDIX C

SAMPLE RESULTS

At Logistic Management Institute's request, DIPEC provided a random sample of approximately 300 of its retention/disposal decisions. Analysis of the data was conducted to determine --

- Which decision framework was employed (judgmental or economic);

- What decisions the economic model generated; and

- How often the economic model was overridden and why.

Data were provided in the form of a completed Economic Decision Formula (DIPEC Form 300A). This computer-generated form shows the item's identification number, I&S Family, PEC number, original acquisition cost, age, technical value, and mobilization and reutilization requirements and the current retention level for the I&S Family, plus all values computed to implement the Retention Evaluation System economic model. The form also shows the results of the model (costs and benefits to add), the actual decision, and comments to support the actual decision, as applicable.

A total sample of 313 decisions was obtained. Of this total, 23 decisions were discarded because retention levels were already met or because no known reutilization requirement exists. A subsample of 290 decisions remained for analysis. Table C-1 displays the composition of this subsample, depending on the purpose for which the item would be added to the General Reserve.

Table C-1 indicates that, in 38.6 percent of the cases, item consideration is only for the purpose of meeting mobilization requirements -- the current inventory level satisfies reutilization requirements but not the

greater mobility requirement. In this case, decisionmaking is judgmental and not based on economic benefit and cost. Our sample indicates that approximately 50 percent of the items considered for this case are retained on judgmental grounds.

TABLE C-1. COMPOSITION OF DECISION SAMPLE

PURPOSE	NUMBER OF DECISIONS	PERCENTAGE OF DECISIONS
To meet mobilization and reutilization requirements	148	51.1
To meet reutilization, mobilization satisfied	30	10.3
SUBTOTAL	178	61.4
To meet mobilization, reutilization satisfied	112	38.6
TOTAL	290	100.0

The Retention Evaluation System is used, in principle, for the remaining 178 decisions, where an item is considered for addition to the General Reserve to meet joint reutilization and mobilization requirements or to meet reutilization requirements alone.

These decisions were examined in some detail, with the following results:

- The economic evaluation model called for retention in 134 instances (75 percent of the time) and called for excessing 44 times (25 percent).

- Of the 134 model-generated retention decisions, 92 were subsequently overridden and the items excessed -- most (70) overrides were based on technical score (below 45 points) and/or age (33 years) with some (22) for other reasons.

- For the 44 decisions where the model called for excessing the item, technical score and age overrides would have led to the same excess decision in all but two cases (one decision was reversed from excess to retain, for other reasons).